



**Application Note: Analyskop EZF/EZFU 6 kHz - 2700 MHz**

# Automatic Frequency and Time Analysis

## FUNCTION SETTING

Modes: frequency domain · time domain  
LIN (26 dB) or LOG (80 dB) amplitude display · AM/FM demodulator

Programming switch: parameter selection

Sweep width, resolution and sweep time are ganged ■ A warning lamp lights if a switch of the EZF is in a wrncg position

### Sweep time

Left: for frequency domain mode · right (for time domain mode): step-wise and continuous 0.12 - 400 msec

Frequency range, 6 bands without change of plug-in

EZF input: 6 kHz - 1.3 MHz/60 kHz - 13 MHz/0.1 - 130 MHz/150 - 170 MHz  
EZFU input: 30 - 1400 MHz/1300 - 2700 MHz

Continuous tuning over all EZF/EZFU bands on EZFU

EZF can be tuned with ○ plug-in crystal or ○ external oscillator  
Input sensitivity 0.1 - 0.5 µV, depending on selected band

Well-defined overdriving of the analyzer up to the actual limit of measurement possible thanks to automatic identification of spurious products

Adjustable level line

Electronically superimposed, no recalibration required · setting of reference level

## FREQUENCY DOMAIN MODE

Shifting of details · reversal · frequency markers

Shifting of subranges with crystal operation

Reversal of frequency axis - important for operation with a converter  
Crystal-controlled linear frequency marker scale (interpolation possible)

Marker spacing ganged with sweep width · centre frequency marker is lower

## TIME DOMAIN MODE

Sweep: stopped for display of modulation time function

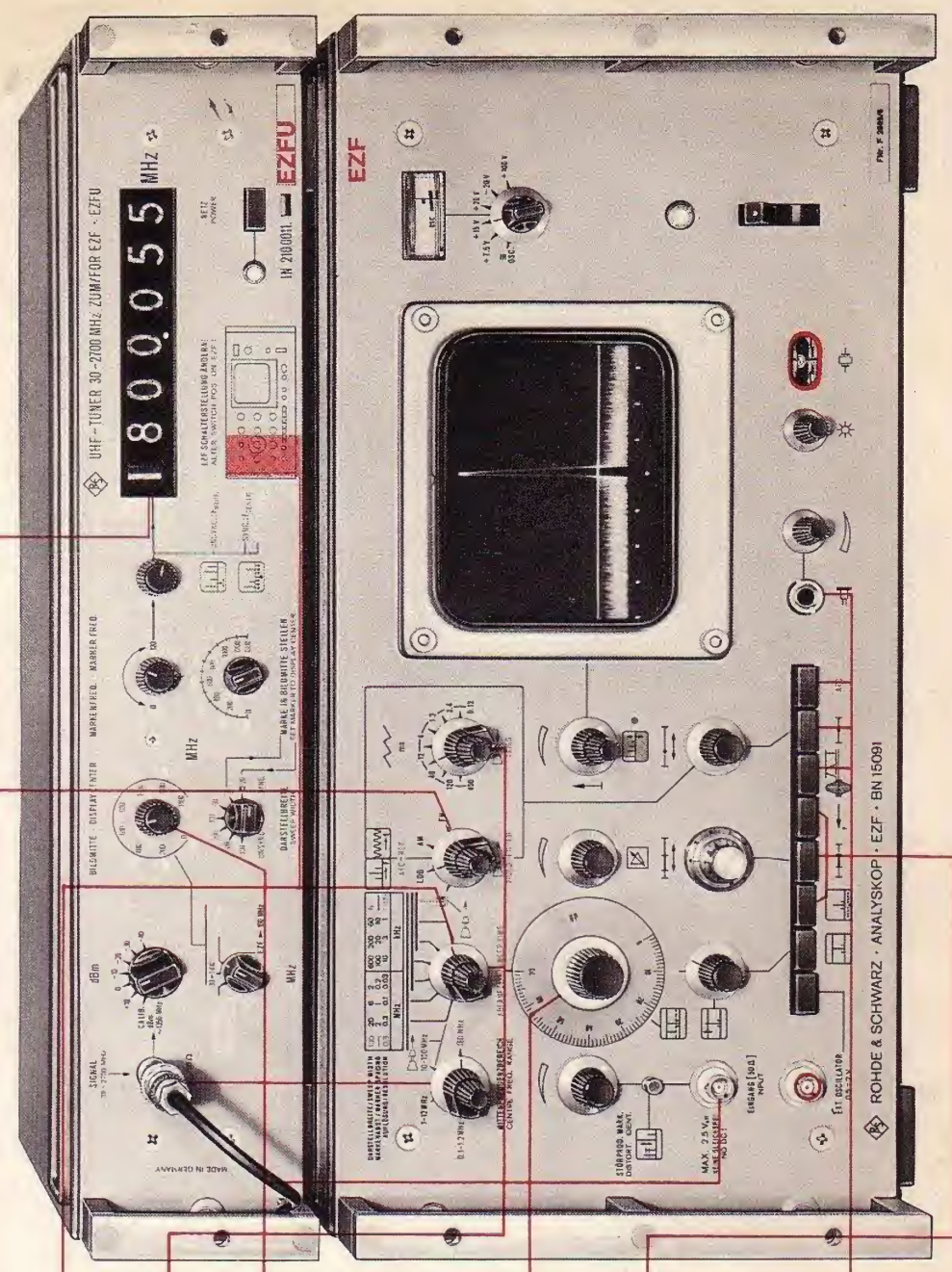
Shiftable bright-up marker identifying the selected signal

Time display for AM and FM · aural monitoring of modulation content possible

Modulation-depth measurement · AFC, switch-selected video filter

## COUNTER READOUT for all frequ. ranges

Sweep width > 20 MHz: freq. of adjustable marker  
Sweep width ≤ 20 MHz: adjusted freq. (centre marker)  
High tuning accuracy and setting accuracy



## MEASUREMENT

Automatic analyzer with visual display of frequency and time functions

Distortion and noise measurements:

harmonic and intermodulation distortion; signal-to-noise ratio

noise and spurious signals

Modulation measurements:

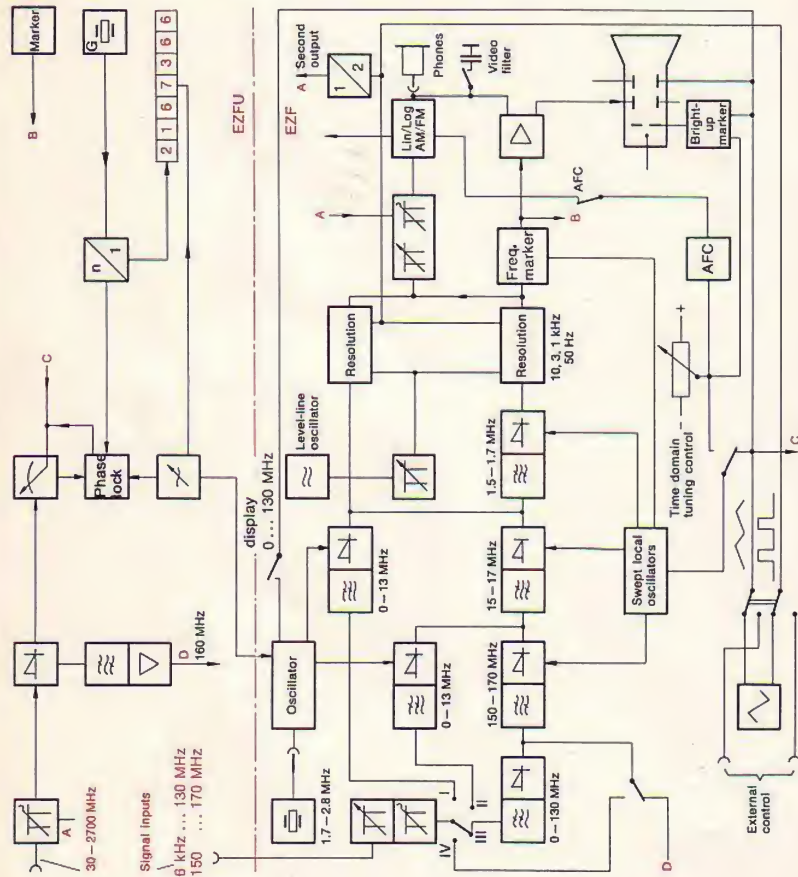
modulation with AM, FM, PM; modulation depth, modulation frequency, pulse width, pulse repetition frequency

Laboratory measurements: Q's of resonant circuits

Radio monitoring:

station identification, checks on band occupation and out-of-band radiation

## TEST ASSEMBLY



## FEATURES

Low phase noise, high frequency accuracy due to crystal-controlled oscillator

Sharp-cutoff filters  $B_3 \text{ dB}/B_{50} \text{ dB} = 1/2.5$

Digital readout in the whole range of 6 kHz - 2.7 GHz

**Automatic marking of inherent spurious products caused by overdriving**

Operating errors are widely precluded

Time-domain display for AM and FM

Resolution (50 Hz - 300 kHz) ganged with sweep width

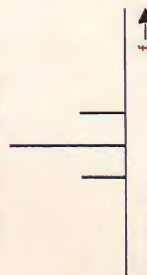
Superimposed frequency markers; level line adjustable with calibrated shift control

Built-in reference level generator

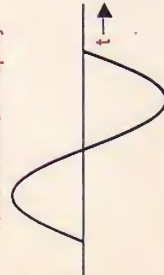
Operation from AC supply 50 - 400 Hz; 100 VA; battery operation possible

## Hint for operation

## Frequency analysis

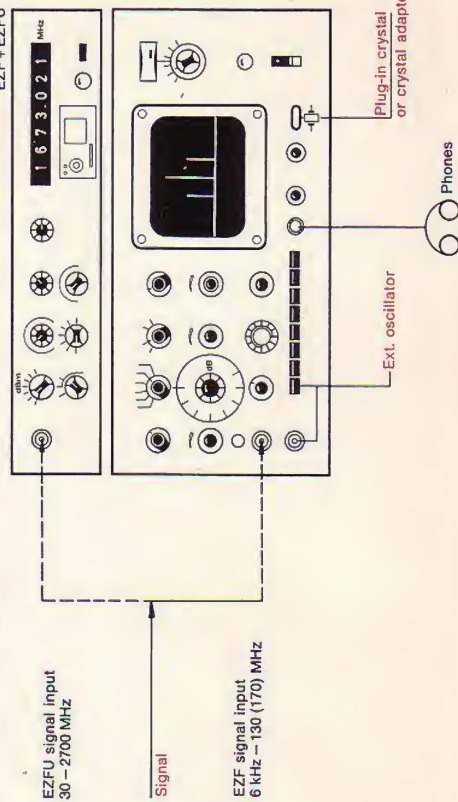


## Time-function display



## Setting EZF + EZFU

EZF + EZFU



## Frequency selection

**Basic Unit EZF alone:**

1st possibility: plug-in crystal or crystal adapter

2nd possibility: external oscillator

**Basic Unit EZF + UHF Tuner EZFU (3rd possibility)**

Frequency setting on EZFU for all subranges from 6 kHz to 2.7 GHz

Seven-digit frequency readout with automatic shifting of decimal point

**Sweep width selection**

**EZF alone:** max. 130 MHz · **EZF + EZFU:** max. 1400 MHz, min. 6 kHz

Spectrum evaluation: see applications

Select the desired signal in the spectrum with the bright-up marker

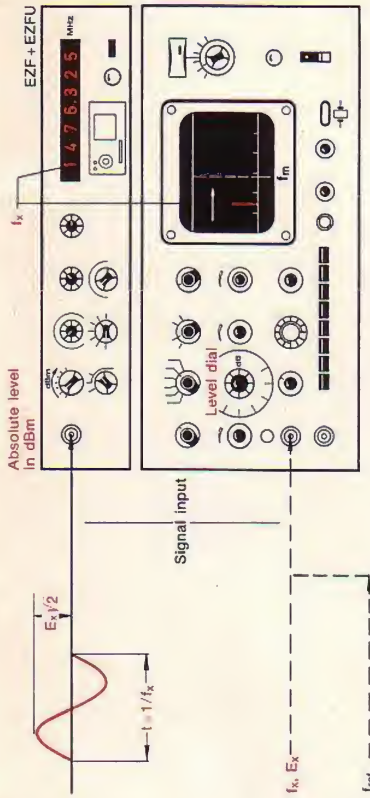
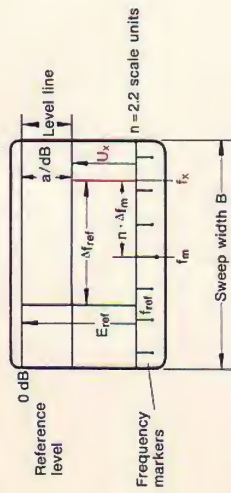
Select the desired type of modulation (AM, FM)

The demodulated signal is displayed as a function of time

The modulation content can simultaneously be monitored via headphones

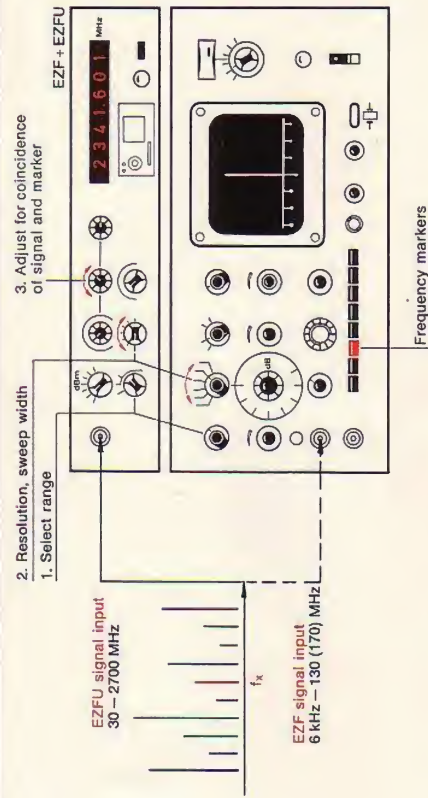
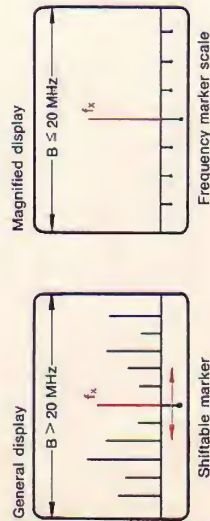
## Measurement of signal frequency and amplitude

### Evaluation of pattern, methods 1 b, 2 a



### Selective frequency measurement with:

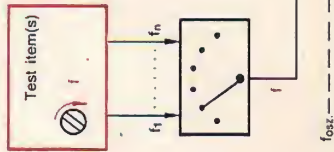
several simultaneous signals, low signal levels, modulated test signals



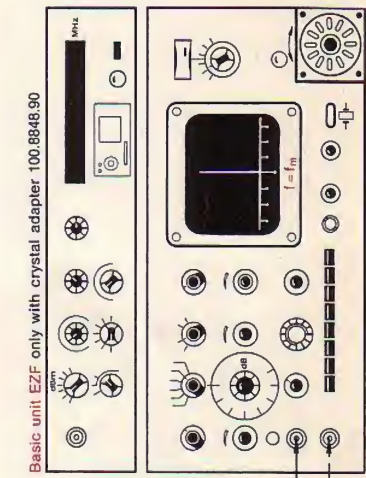
### Measurements at fixed frequencies

#### Typical applications in test departments:

IF measurement/adjustment of radiotelephone receivers  
Video signal: vision and sound carriers, colour subcarrier



### Long-term frequency recording



Easy setting and rapid changing of nominal frequency ( $f_{nom} = f_m$ ) with the selector switch of the crystal adapter allows short checking and adjusting times. Max. 12 crystal frequencies ( $f_Q = k \times f_m$ ) can be selected;  $k = 1, 0.1, 0.01$ , depending on range

Dashed in the diagram: second possibility of fixed-frequency tuning, with highly stable external oscillator  $f_{osc}$ ; suitable for precise long-time frequency recording (EZF + recorder) The EZF + EZFU combination allows continuous tuning by EZFU with digital readout

### Frequency measurement

- Reference: centre-frequency marker  $f_m$ 
  - Most subtle method using EZF/EZFU combination: bring signal  $f_x$  to coincide with centre frequency  $f_m$ , reduce sweep width B stepwise to obtain the desired resolution. Read frequency  $f_x$  on counter
  - Without EZFU counter. Read from the screen display (see diagram in the left column):  $f_x = f_m (\pm) n \Delta f_m$
- Reference: reference signal  $f_{ref}$ ; a) read from the screen display (see diagram in the left column):  $f_x = f_{ref} (\pm) \Delta f_{ref} = f_{ref} \pm m \Delta f_m$ 
  - Zero-beat method:  $f_x \rightarrow f_{ref}$

### Amplitude ratio

Absolute in dBm: direct on EZFU attenuator

Relative: the level reading "a" in dB (on level dial) is used to calculate the voltage ratio

$$E_x = 10^{\frac{-a}{20}} \text{ or power ratio } P_x = 10^{\frac{-a}{10}}$$

$$E_{ref} = 10^{\frac{-a}{20}} \text{ or power ratio } P_{ref}$$

### High tuning accuracy and counter resolution

Counter resolution EZF: 10 Hz/ -/1 kHz depending on sub-range EZF/EZFU: 1 kHz

Advantage over direct-reading frequency meter: individual frequency components of a spectrum can be exactly selected and measured

Measurement (see diagrams in the left column)

General display: coarse location of signal

Reduce sweep width stepwise to obtain the desired reading accuracy, e.g. B = 60 kHz; accuracy  $\pm 10$  kHz at max. 2.7 GHz

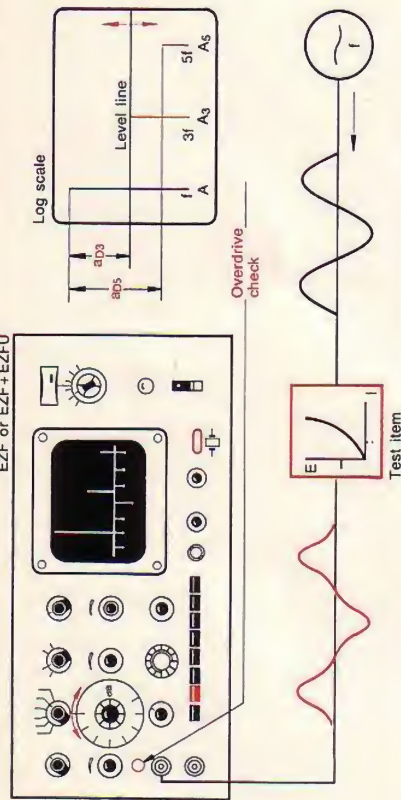
## MEASUREMENT

Measurement of harmonic ratio and distortion factor (single-tone method)

Example: range up to 130 MHz

## TEST ASSEMBLY

## FEATURES

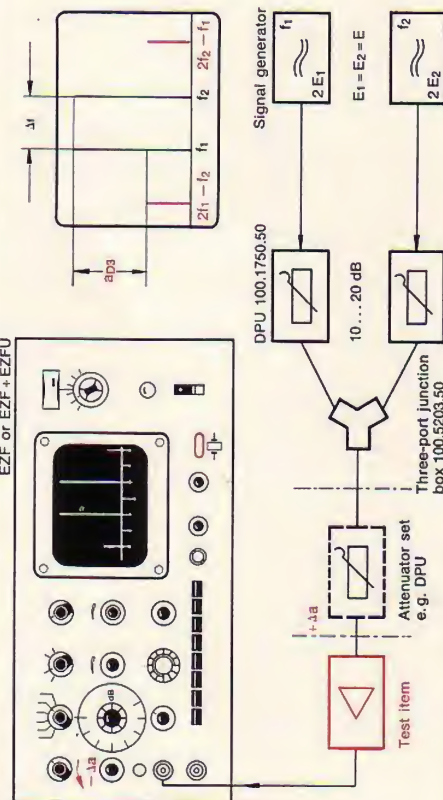


At a glance: amplitudes and distribution of harmonics  
No switching of resolving bandwidth when changing from LIN to LOG display (sharp-cutoff filters)  
Harmonic ratio  $a_{Dn}$  can be directly measured with calibrated adjustable level line  
Definition:  $a_{Dn}/dB = -20 \log D_n$   
Distortion factor of individual component:  $D_n \approx A_n/A$   
Overdriving does not lead the user to misinterpret the display: inherent spurious products are displayed with half the sweep frequency; their amplitude  $A_n$  changes by  $n$  dB according to the order  $n$  when the OVERDRIVE CHECK button is depressed ( $\Delta A_3 = -3$  dB;  $\Delta A_5 = -5$  dB; etc.)

Measurement of intermodulation distortion ratio  $a_{Dn}$   
(signal amplitude \*  $E_1 = E_2 = E$ )  
The method is particularly suitable for selective test items when signal frequency and interference frequency are close to each other

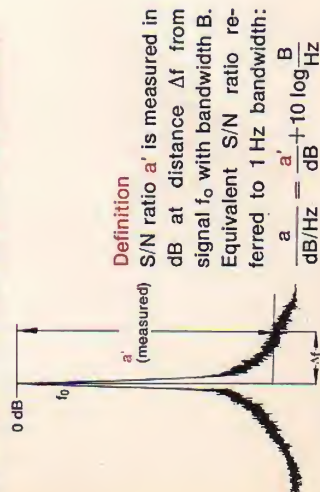
Example: intermodulation distortion ratio  $a_{D3}$  (3rd-order intermodulation product) of an amplifier

\* For the intermodulation method:  $E_1 > E_2$



Short sweep time with high selectivity  
Hint for setting: sweep width 60 kHz, resolution 1 kHz,  $f_2 - f_1 \geq 10$  kHz  
Take the reading at  $a_{D3}/dB = -20 \log d_3$   
Test hint: When the test item has a broadband input, connect a lowpass filter into the signal path to suppress the generator harmonics  $2f_1$  ( $2f_2$ )  
Poor decoupling of the signal generator results in intermodulation distortion ahead of the test item: upon variation of the attenuator setting,  $a_{D3}$  remains constant  
If  $a_{D3}$  test item  $> a_{D3}$  analyzer ( $> 70$  dB, automatic check), extension of dynamic range by accurately defined overdriving of test item  
Relation: with a linear increase of the signal level  $\Delta a$  by  $n$  dB,  $a_{D3}$  decreases by  $2n$  dB

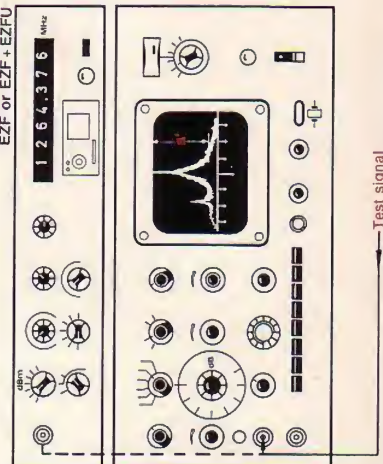
Measurement of S/N ratio and noise sidebands



## Definition

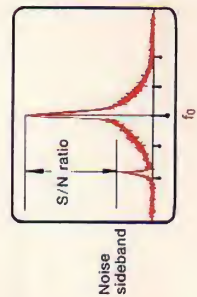
S/N ratio  $a'$  is measured in dB at distance  $\Delta f$  from signal  $f_0$  with bandwidth B. Equivalent S/N ratio referred to 1 Hz bandwidth:

$$\frac{a}{dB/Hz} = \frac{a'}{dB} + 10 \log \frac{B}{Hz}$$



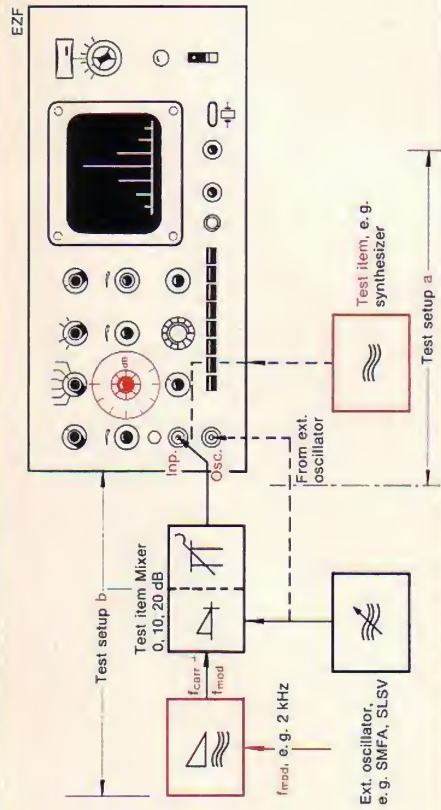
High inherent S/N ratio of internal oscillators: 110 - 130 dB/Hz at 10 kHz from  $f_0$ , depending on selected subrange  
Example (for definition see Measurement column): resolution (bandwidth)  $B = 1$  kHz, marker spacing  $\Delta f = 10$  kHz, sweep time 0.6 sec. Measured S/N ratio  $a' = 70$  dB  
Equivalent S/N ratio:

$$\frac{a}{dB/Hz} = 70 \text{ dB} + 10 \log \frac{1000 \text{ Hz}}{1 \text{ Hz}} = (70 + 30) \text{ dB} = 100 \text{ dB}$$



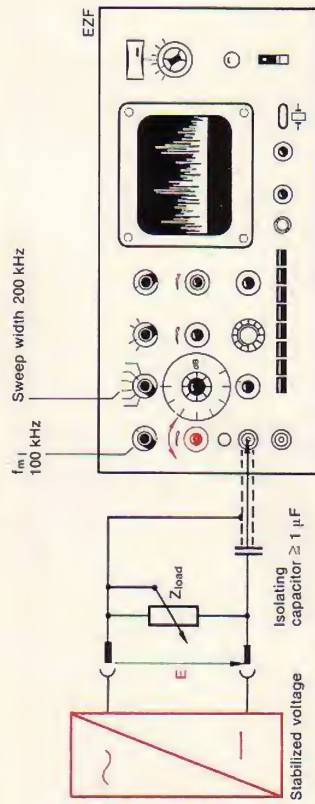
Measurement of extremely high S/N ratios; noise sidebands down 130 dB/Hz at 10 kHz from carrier

1. at 1 MHz (EZF with crystal adapter) or at 160 MHz (EZF only, no input oscillator operating)
2. test setup a, range 60 kHz — 13 MHz, 10 kHz — 130 MHz (EZF with low-noise external oscillator)
3. test setup b (EZF with Mixer Ident No. 111.8915.02 and external oscillator) for adjacent-channel measurement of radio-telephone systems

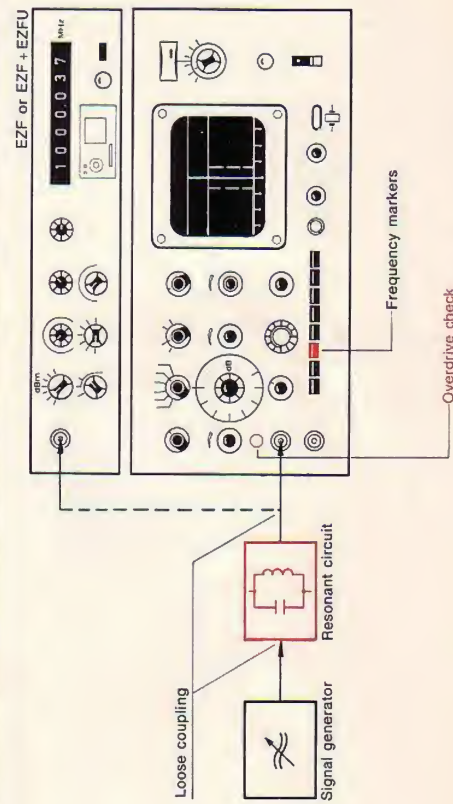


Analysis of noise spectra in stabilized supply voltages

This analysis is particularly useful when a noise spectrum superimposed on a stabilized supply voltage risks to impair the performance of the circuit being operated ( $Z_{load}$ ), e.g. a voltage-tuned oscillator

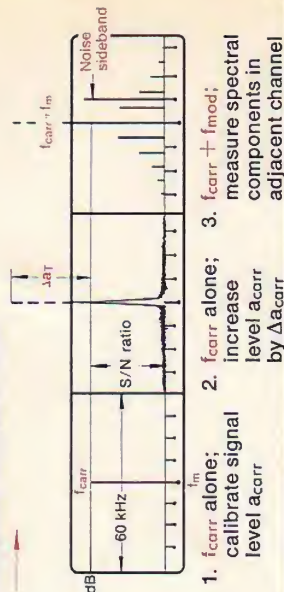


Precise Q measurement of resonant circuits ( $Q > 1000$ ) in conjunction with a signal generator



Test setup a is suitable for checking high-quality frequency sources for spectral purity in the range 10 kHz — 130 MHz. Test setup b allows analysis of noise sidebands, e.g. measurement of adjacent-channel cross-modulation.

Schematic of measurement:



Full input sensitivity even at the lower frequency limit of 6 kHz thanks to low-noise oscillator

High selectivity with good noise bandwidth

Short sweep time

Note: Take care that the input control of the Analyoskop is not set for full sensitivity when the test item is connected or disconnected, because of the resulting current surge!

A "by-product" of the automatic overdrive check facilitates the measurement: the 3-dB level-line jump. When the OVER-DRIVE CHECK button is depressed, a double line representing the reference values 0 and -3 dB is displayed.

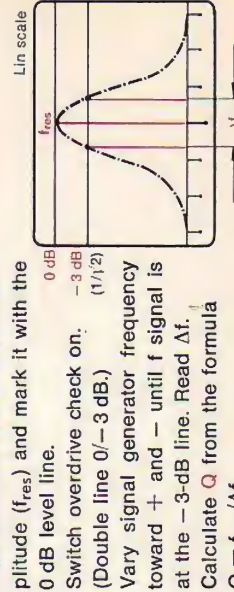
Measurement: Find maximum amplitude ( $f_{res}$ ) and mark it with the 0 dB level line.

Switch overdrive check on: -3 dB (Double line 0/-3 dB.)

Vary signal generator frequency toward + and - until f signal is at the -3 dB line. Read  $\Delta f$ .

Calculate Q from the formula

$$Q = f_{res}/\Delta f$$

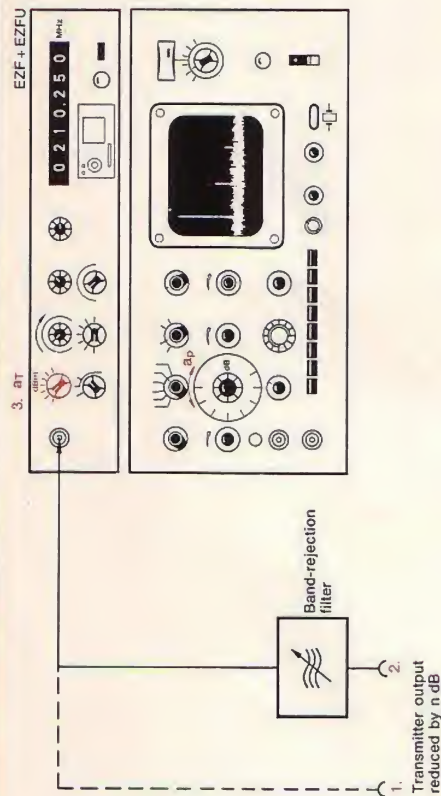


Measurement of harmonic radiation of broadcasting and TV transmitters up to 2.7 GHz

Example: TV transmitter for Band III, carrier power 20 kW  
Permissible harmonic power  $\leq 20$  mW according to standard specifications

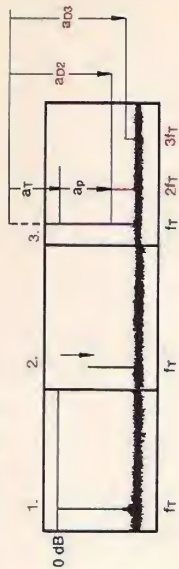
Harmonics measurements on Band V transmitters do not require a band-rejection filter since the fundamental and harmonics lie in different reception ranges of the Analyskop

## TEST ASSEMBLY



## FEATURES

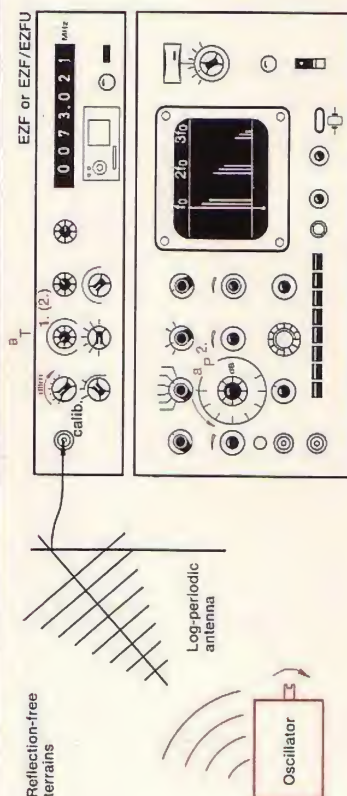
High tuning accuracy allows harmonics measurements with small sweep width  
Procedure →



1. Adjust carrier alone to within level range of Analyskop
  2. Tune band-rejection filter to carrier (carrier reduction  $\approx 25$  to 40 dB)
  3. Reduce input attenuator by  $a_{corr}$
- Measure level ratio with level line  
Example: Adjustment of attenuator  $a_{corr} = -30$  dB, of level line  $a_p = -36$  dB;  $a_{D2} = a_{corr} + a_p = -66$  dB  
With  $P_{corr} = 20$  kW, harmonic power  $P_{D2} = 5$  mW

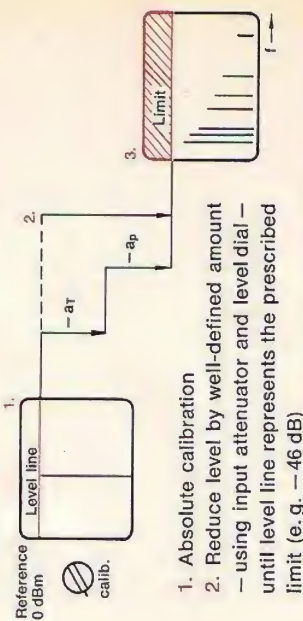
Measurement of oscillator reradiation according to VDE 0871-9 (acceptance test)

## Reradiation measurement



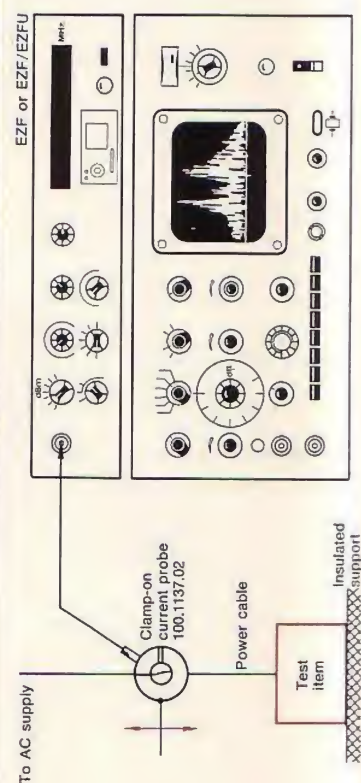
Built-in standardizing oscillator for absolute level measurements in the range 30 – 2700 MHz

## Procedure →



Direct measurement of spurious RF energy from 30 to 300 MHz transmitted from a (sine-wave) noise source through the power cable

Also: measurement of sheath currents in coaxial cables



Adjust clamp-on current probe for maximum spurious energy  
Weighted measurement of pulse interference is possible only by an integrating method

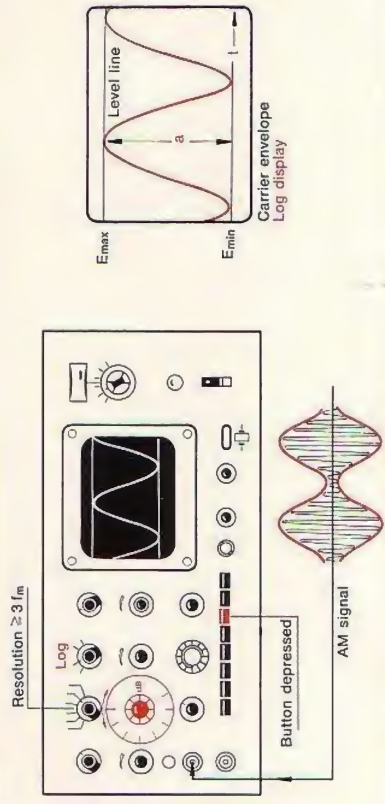
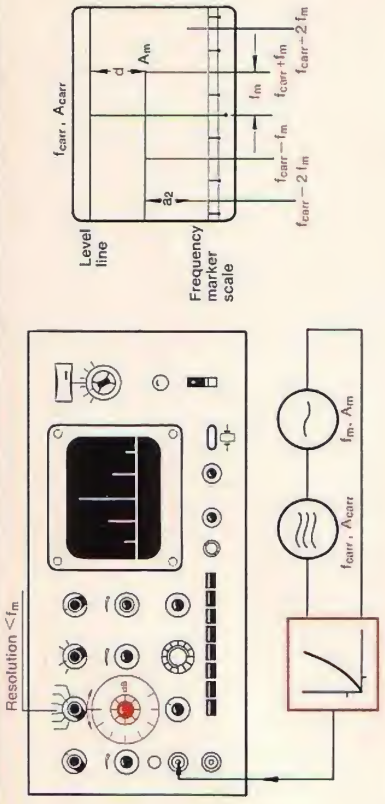
# AM measurements on modulators

Suitable method: use of frequency spectrum for small modulation depths; using time domain mode for large modulation depths

Example: determination of small modulation depths from frequency spectrum of sinusoidal amplitude-modulated RF carrier

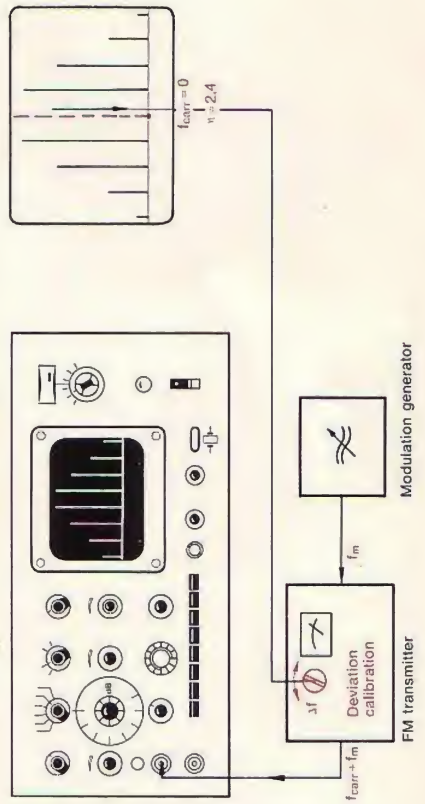
Example: determination of large modulation depths by the envelope method ( $m > 0.9$ )

## Measurements on modulators



# FM measurement on signal generator

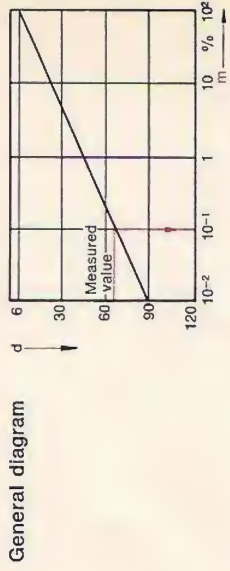
Deviation calibration of FM transmitter



Modulation distortion directly measurable in dB below carrier amplitude by means of level line  
Modulation depth measurable down to  $m = 0.02\%$   
Example: measured  $d = 66$  dB or  $A_m/A_{carr} = 5 \times 10^{-4}$

Calculation:

$$m = 10 \frac{6-d}{20} = \frac{2 A_m}{A_{carr}} = 10^{-3} \text{ or } 0.1\%$$



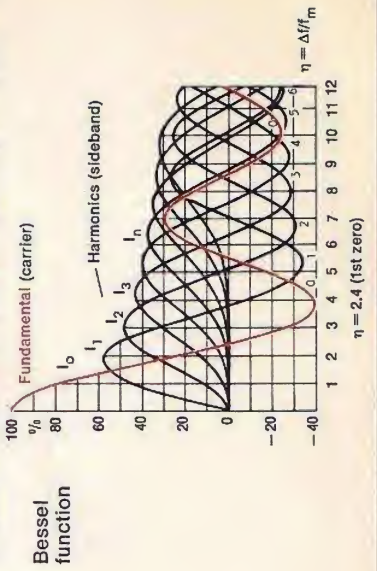
Tracking level line for accurate measurement requiring no recalibration. The wide dynamic range of 70 dB allows modulation depths up to  $m = 99.95\%$  to be measured.

From the measured value  $a$  one calculates

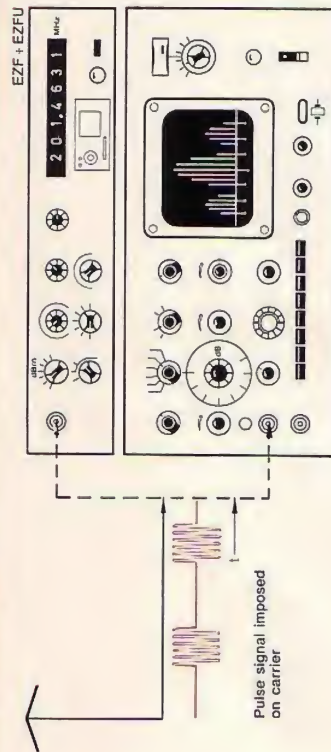
$$\Delta x = E_{min}/E_{max} = 10^{-a/20}; m = \frac{1 - \Delta x}{1 + \Delta x} \approx 1 - 2 \Delta x$$

Example: measured  $a = 60$  dB;  $\Delta x = 10^{-3}$  gives a modulation depth  $m \approx 1 - 2 \times 10^{-3} \approx 0.998$  or  $99.8\%$

Measurement: Take modulation index  $\eta$  from a zero of the Bessel function. Preferably choose 1st zero  $\eta = 2.4$  of carrier since here the distortion of the modulation generator does not enter into the measurement  
Calculate associated modulation frequency  $f_m = \Delta f/\eta$   
( $\Delta f =$  predetermined deviation reference value) and adjust  $f_m$ . Vary deviation until carrier  $f_{carr}$  disappears. This zero is the criterion for the  $\Delta f$  reference point, e.g.  $\Delta f = 100$  kHz = FS



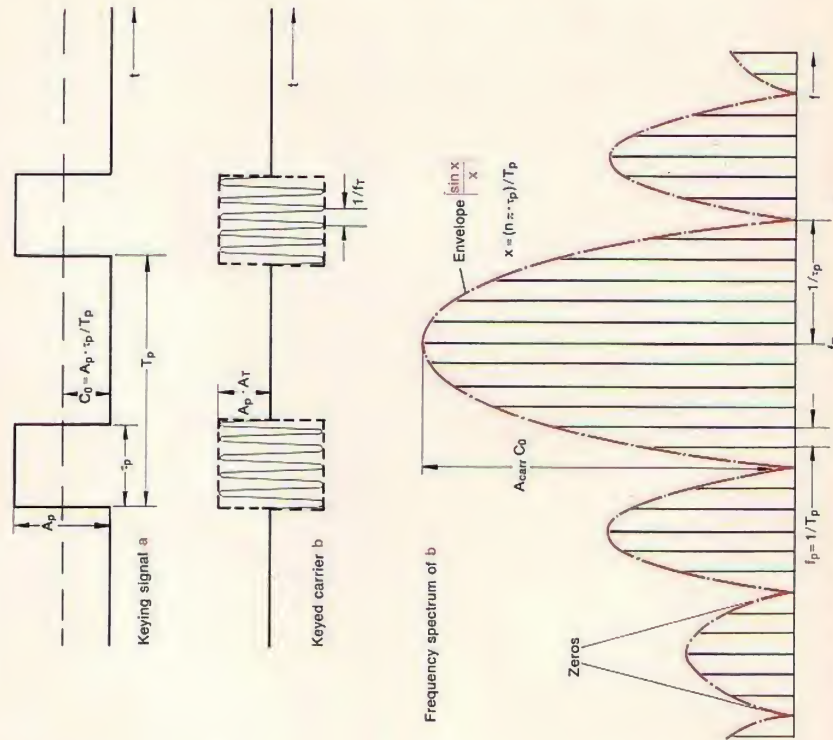
Evaluation of pulse-modulated carrier, i.e. determination of typical pulse data (time domain) from the spectrum displayed (frequency domain)



High sweep speed together with high selectivity (sharp cut-off filters)  
Resolution and sweep-width selection are ganged so that faulty settings are precluded  
Frequency measurement: linear frequency marker scale (interpolation possible) with crystal-controlled centre marker  
Amplitude measurement: superimposed level line, accurate without recalibration, adjustable with calibrated shift control covering  $> 80$  dB  
Test hint: For exact determination of pulse repetition frequency  $f_p = 1/T_p$  select a detail (high resolution)  
For determining pulse width  $\tau_p$  select great sweep width

Quantitative evaluation of random noise, i.e. of non-periodic energy surges is possible only with integrating measurements

The analytical method of the Analyskop EZF/EZFU gives an uncalibrated survey of the noise intensity distribution or is used to check noise-reducing measures



Quantitative evaluation of the spectrogram (valid also if the pulses are not of squarewave form):

1. Amplitudes of individual spectral lines.
2. Number of spectral lines up to the first zero is the duty cycle  $T_p / \tau_p$ .
3. Distance between two neighbouring spectral lines corresponds to pulse repetition frequency  $f_p$ .
4. Zeros are at  $f_{carr} \pm n/T_p$  ( $T_p = \text{pulse width}$ )

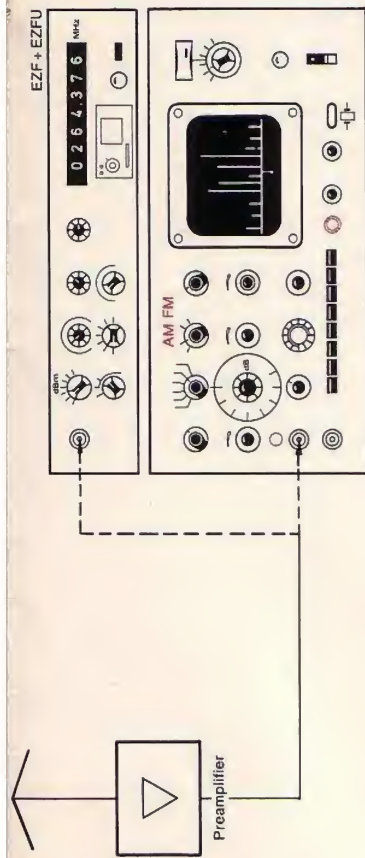
Qualitative evaluation of the envelope:

The total frequency range covered by spectral lines depends on the pulse width  $\tau_p$ , e.g.  $\tau_p = 0$ ;  $\Delta f = \infty$ . The area enclosed by the envelope represents the power distribution: the spectral lines between the first zeros ( $f_{carr} \pm 1/T_p$ ) constitute the main contribution, the others mainly determine the waveform. Any asymmetry of the spectrum about  $f_{carr}$ , for example, indicates detuning of the transmitter-output circuit

# Radio monitoring of RF signals for:

band occupation,  
type of modulation, modulation depth,  
frequency deviation, frequency stability,  
time-domain display of modulation

The Preamplifier Ident. No. 104.0458.90 is used  
to compensate for line losses and to increase  
sensitivity.



## Radio monitoring

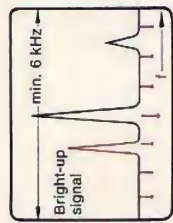
Measurements and measuring facilities in frequency domain and time domain modes

### Frequency domain mode

Magnified display: reliable identification of a signal for amplitude and frequency with electronically superimposed level line and crystal controlled frequency-marker scale  
Spurious products are recognized; they are represented in the frequency display as spectral lines with fluctuating amplitude  
Adjustable base line clipper

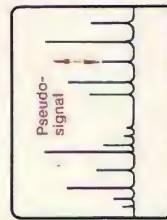


Identification of spurious products

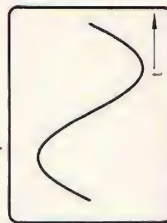


Frequency domain mode  
General display + Magnified

Time domain display



Aural and visual monitoring of AF signal

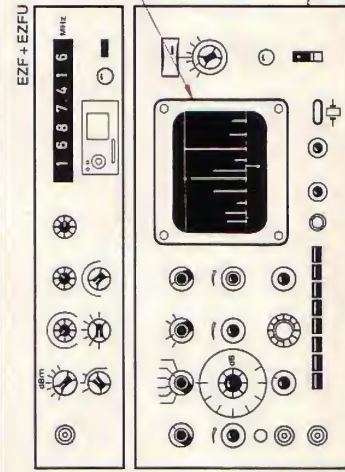


### Time domain mode

Presetting for transition from frequency domain to time domain mode: shiftable bright-up marker identifies a selected signal in the spectrum  
Simultaneous aural monitoring and visual display of demodulated information: AM, FM, AFC switch-selected

Recording of patterns, for example, of a particular band occupation

- a) XY recorder  
e.g. ZSK  
YT recorder  
e.g. ZSG 2
- b) Camera adapter



a) Direct transition from EZF display to recording and vice versa  
No problems of level adjustment and scale conversion for level line (staircase or line pattern), and frequency marker (marker scale displayed below zero line)  
Pattern synchronous with recording; setting of starting level during observation of pattern. Sweep time  $\leq 3$  min, manual or remote sweep control also possible, single or periodic sweep

## Recording

a) XY Recorder  
ZSK

## Signal input

Input frequency range, switch selected	I	II	III	IV	V	EZFU
Input frequency	6 kHz — 1.3 MHz	60 kHz — 13 MHz	100 kHz — 130 MHz	150 — 170 MHz	30 — 1400 MHz	1300 — 2700 MHz
Max. sweep width <sup>1)</sup>	200 kHz	2 MHz	130 MHz	20 MHz	1400 MHz	1400 MHz
Sensitivity at 1 kHz resolution (signal + noise = 2x noise)	≤ 0.5 μV	≤ 1 μV	≤ 1.5 μV	≤ 1 μV	≤ 1.5 μV	≤ 1.5 μV
Input attenuator						
Level range		continuous ≥ 60 dB				50 dB in 10-dB steps
Gain adjustment of IF attenuator		operating range 146 dB				absolute + 10 to —122 dBm, calibrated
Dynamic range (spurious products appear in the basic noise)		continuous > 100 dB; no influence on calibration, since level line follows				
		with 1 kHz resolution: third-order intermodulation products better than —75 dB;				
		automatic identification of inherent spurious products caused by overdriving				

## FUNCTIONAL SETTING

Input frequency tuning (centre frequency)	for EZF ranges I, II, III	EZFU ranges V, VI
by internal oscillator in UHF Tuner EZFU		
by plug-in crystal or plug-in crystal adapter carrying 12 crystals		1.7 — 2.8 MHz, EZF ranges I, II, III
by external oscillator		for EZF ranges I, II, III; $f_{osc} = 170 - 280$ MHz, $E_{osc} = 1 - 2$ V
Amplitude display	lin 26 dB; log 80 dB; amplitude error over display range ≤ ±0.5 dB	

## FREQUENCY DOMAIN

Sweep width	6 kHz	200 kHz	600 kHz	2 MHz	6 MHz	20 MHz	20, 50, 100, 200, 500, 1400 MHz
Resolution	50 Hz	3 kHz	10 kHz	30 kHz	100 kHz	300 kHz	ganged (300 kHz) or arbitrary
Frequency marker spacing	—	20 kHz	100 kHz	200 kHz	1 MHz	2 MHz	—
Minimum sweep duration, automatic	0.7/0.4 sec	200 msec	60 msec	20 msec	20 msec	20 msec	20 — 200 msec
Frequency markers <sup>2)</sup>		for sweep widths ≤ 20 MHz: linear scale with centre marker; with EZFU at sweep widths > 20 MHz: shiftable single marker					
Frequency axis							
Frequency readout							
<sup>1)</sup> Also with crystal tuning, any sweep width can be selected and centred anywhere within the maximum sweep range (subrange limits) · <sup>2)</sup> Frequency markers: displayed below base line; extended centre-frequency marker; marker spacing ganged with sweep width							

## TIME DOMAIN MODE

Demodulation of AM and FM possible with all IF bandwidths (resolution)	
Modulation-frequency range (AM, FM)	10 Hz — 50 kHz
Time-base triggering	automatic from signal, can be switched off
Sweep time	in steps of 0.12/0.4/1.2/4/12/40/120/400 msec; continuously adjustable between steps
Video filter with AM demodulation	1-kHz lowpass filter, improving S/N ratio of AF signals
Phones output ( $Z \leq 100 \Omega$ )	for 4 k $\Omega$ load $E_{out max} = 6$ V; for 1 k $\Omega$ load $E_{out max} = 2$ V

## Level line

Calibrated shift in the amplitude range	0 to —70 dB
Range extension	over more than —80 dB
Error above 70 dB	≤ 1 dB

## Connectors

Input for external control functions	
Outputs for XY signal, several pulse and DC voltages	

# **RECORDER ADAPTER Ident. No. 103.5227.02**

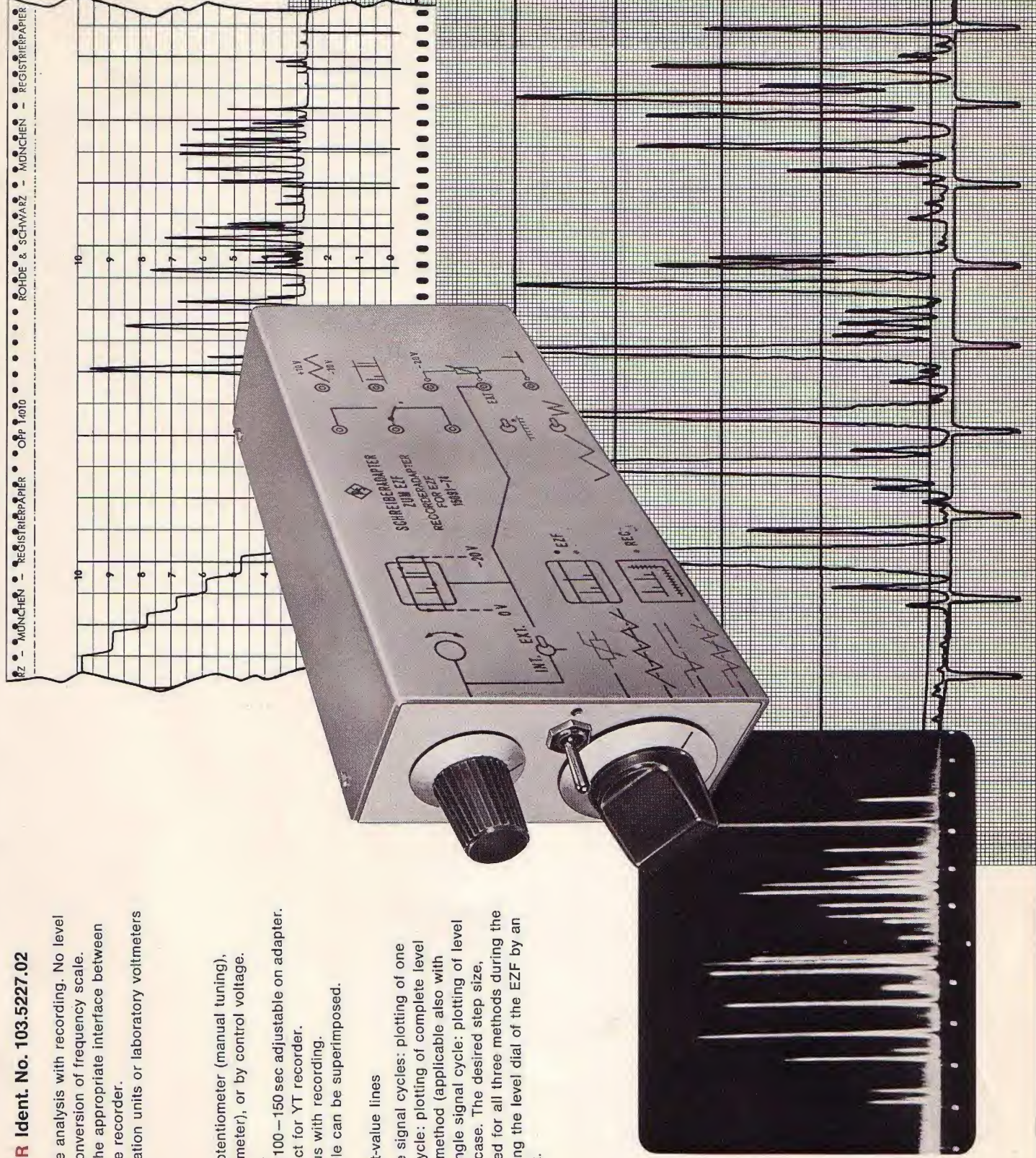
Perfect frequency and time analysis with recording. No level adjustment problem. No conversion of frequency scale. The Recorder Adapter is the appropriate interface between the Analyskop EZF and the recorder. XY or YT recorders, evaluation units or laboratory voltmeters are used as peripherals.

## **Sweep control**

Internal via sawtooth or potentiometer (manual tuning), external (tracking potentiometer), or by control voltage. Single or recurrent sweep. Sweep time: 30 – 50 sec or 100 – 150 sec adjustable on adapter. Floating changeover contact for YT recorder. Screen pattern synchronous with recording. EZF frequency marker scale can be superimposed.

## **Level-line graticule or limit-value lines**

1. Between two successive signal cycles: plotting of one level line. 2. After single cycle: plotting of complete level line graticule. 3. Quickest method (applicable also with YT recorders): before a single signal cycle: plotting of level lines in the form of a staircase. The desired step size, e.g. 10-dB steps, is selected for all three methods during the level-line period by adjusting the level dial of the EZF by an accurately defined amount.



12 - MÜNCHEN - REGISTRIERPAPIER - OP 14010 - RÖHDE & SCHWARZ - MÜNCHEN - REGISTRIERPAPIER